Editorial

The role of artificial intelligence in knowledge management

1. General ambit of knowledge management

Knowledge Management (KM) has emerged as a predominantly management discipline in the early to mid-90s. The American Productivity and Quality Centre has identified six common strategic elements [1] among US firms that have embraced this new field. Two elements are the *formulation of business strategies* and the appointment of *Chief Knowledge Officers* to better focus on the exploitation of core intellectual assets by business and Governments, specifically the need to capitalise on increasingly expensive human resources/process knowledge to achieve competitive advantage in global procurement (supply chain management), in product development, in customer relationship management (CRM) and in value-added services.

It soon became obvious that to tackle KM well, contributions from, among others, diversified areas spanning management, human resources, decision science, marketing, artificial intelligence (AI) and knowledge modelling are needed. For practical purposes, the guest editors consider KM as a discipline that encompasses processes and techniques for the creation, collection, indexing, organisation, distribution, access to and evaluation of institutional knowledge for improvement of performance, and more generally, for the exploitation of intellectual capital, including reuse opportunities. In order to establish seamless KM processes that cover the above aspects, cultural and human resource issues should be considered as well as the development of intelligent (e.g. knowledge capturing and sharing) systems that enhance the performance and execution of the ever-increasing, common knowledge-intensive tasks facing organisations today.

As for the role and significance of AI in KM, there are two questions that are commonly encountered by AI researchers moving into the KM arena. The first question is "After decades of research in Knowledge Engineering, what exactly is KM? Is it merely another term (or "brand name") for essentially the same concept?" The business response is a resounding NO!

While it would, no doubt, be appreciated that Knowledge Engineering and KM are not disjunctive areas of expertise, Knowledge Engineering has, by general consensus, a far more technical focus on knowledge (e.g. representation, organisation, reasoning, searching etc.). KM, in contrast, is more aligned with the goals of capturing, sharing and reusing knowledge in an organisation or among organisations. In other words, techniques developed in Knowledge Engineering are analogous to "micro" knowledge strategies, whereas approaches to KM are generally considered as "macro" knowledge strategies for an organisation or organisations. As such, KM projects can proceed without any Knowledge Engineering efforts (e.g. a people-based KM system), but the editors are of the view that, ideally speaking, every KM project should embrace some Knowledge Engineering (or AI or Web-based business rules execution) expertise to (attempt to) provide the value-added services often needed in knowledge processing.

The second common question about AI in KM is "There is still no AI system that can converse with a human. The technology is not ready yet. Should one nonetheless attempt to tackle the even more difficult problems in KM?" The general answer for this question is very simple; namely, most sophisticated commercial KM tools already embed some form of AI technology: Bayesian reasoning, ontologies, data mining (DM), intelligent agents to name a few. As a member of an industrial expert systems team for more than a decade, the primary guest editor's observation is that the emphasis on developing fully-fledged AI (or expert) systems has very much shifted. Due to advances in Web-based technology and component-based development, there are, in fact, plenty of opportunities for well-developed/understood AI techniques to be used in various parts of core business processes e.g. user profiling, personalisation of human–computer interactions, content management, case-based retrieval techniques etc.

At present, three dominant streams of research/applications of KM may be readily identified:

- The first stream focusses primarily on research into the theory of knowledge, the knowledge of the firm [2–5], organisational culture [6,7], measurement of intellectual capital [8–10] and learning organisations [11–17]. These researchers tackle the theoretical aspects of KM and some are even challenging Nonaka and Takeuchi's framework for the socialisation and externalisation of knowledge.
- The second stream is represented by the work on corporate memories (also known as organisational memory or organisational memory information systems (OMIS)) for

enhanced decision making. A corporate memory embraces all forms of institutional knowledge, whether formally encoded within the current information systems, or tacit (informal) knowledge used by individuals in professional practice. (Verbal instructions by supervisors, for example, are not usually captured at source!) Representative work in this area includes [14,18–22]. This group has a strong focus on knowledge sharing and on practical applications of KM.

- The third stream, with a strong contribution from computer scientists and AI researchers in particular, tackles the areas of intelligent agents [23–27], ontologies [28–36], and computer-mediated collaborations [37–41].

It is interesting to note that researchers from the areas of AI, KM and Organisational Memory dominate above streams of research not because of the terminological definition of these fields, but very much attributed to the underlying common principles and objectives that these researchers sought to achieve. As a result, the systems developed and/or concepts proposed by these researchers focus on: (i) organization of knowledge; (ii) formalization of knowledge; and (iii) contexts of knowledge.

With regard to the third stream, publications to 1999 have shown a strong bias in favour of techniques for searching *Intranet/Internet information/documents,* thereby overlooking, in the editors' opinion, other potential benefits that AI techniques might deliver for core KM activities like knowledge discovery (KD) (e.g. mining of interest profile, connecting people of common interest in an organisation), indexing and representation (i.e. the issues of re-organising and retiring knowledge), and knowledge fusion (i.e. combining existing knowledge to generate new knowledge). Furthermore, very few practical applications of KM systems have been reported. This special issue is intended to redress such an apparent imbalance by emphasising the significance and diversity of knowledge processing in the corporate management of knowledge. The call for papers for this special issue has been specifically 'crafted' to attract submissions from industry and academia that address the above opportunities.

2. KBS's leadership role in KM

Prior to the announcement of this special issue, at least four other journals launched special issues on KM:

- IEE intelligent systems and their applications — special issue of knowledge management and the internet vol. 15, no. 3, May/June 2000.
- Strategic Management Journal — vol. 17, Winter, 1996. The title of this special issue is "Knowledge and the Firm".
- Long Range Planning — vol. 30, no. 3, June, 1997. Papers published in this special issue are very much on the theory of knowledge and the measurement of

intellectual capital in an organisation (i.e. the first stream described above).

- Expert Systems with Applications — vol. 13, no. 1, September, 1997. This special issue has a well-balanced set of papers, with a strong emphasis on the use of AI techniques in KM.

Furthermore, a plethora of workshops, symposiums and seminars have been conducted in the area of AI, Organisational Memory and KM, including:

- AAAI Fall Symposium on "AI Applications in Knowledge Navigation and Retrieval" in 1995
- AAAI Workshop on "Using AI in Electronic Commerce, Virtual Organisations and Enterprise KM to Re-engineer the Corporation" in 1997
- Conference on "Practical Aspects of Knowledge Management" (PAKM) in 1996, 1998
- AAAI Spring Symposium on "AI in Knowledge Management" in 1997
- AAAI Spring Symposium on "Ontological Engineering" in 1997
- ECAI Workshop on "Interdisciplinary Workshop on Building, Maintaining, and Using Organisational Memories" in 1998
- Conference on "Practical Applications in Knowledge Management" (PAKeM) in 1998, 1999, 2000
- Workshop on "Knowledge Acquisition, Modeling and Management" (KAW) in 1999
- AAAI Workshop on "Synergies of Knowledge Management and Case-based Reasoning" in 1999
- ES99 Workshop on "Using AI to enable Knowledge Management" in 1999
- IJCAI Workshop on "Knowledge Management and Organisational Memory" in 1999
- AAAI Spring Symposium on "Bringing Knowledge to Business Processes" in 2000
- Dagstuhl Seminar on "Organisational Memory: an Interdisciplinary Approach" in 2000
- 1st Workshop on "Intelligent Systems in the Knowledge-Driven Economy" (ISKDE) in 2000.

The announcement in 1999 of a special issue on *Artificial Intelligence in Knowledge Management* by the editors of the Knowledge-Based Systems (KBS) journal stimulated considerable interest from academics and practitioners, reflecting a growing business awareness of the need to leverage knowledge assets. The need for leadership in KM arises partly from the multiple interpretations, sometimes conflicting, which characterised the early experimental models. More recently, the overarching drivers of global trade dynamics, asset management and technological change has challenged organisational responsiveness in new ways, often demanding new business models better suited to market leadership and trading partner requirements. While there is general agreement that KM has a

significant role to play in facilitating the design and introduction of new business processes, the mapping of knowledge processing practices and corporate memory requirements to business intelligence and competitive advantage benefits has not, to our knowledge, been attempted before in a scholarly journal.

Guest editors for the special issue are Eric Tsui (Computer Sciences Corporation and University of Technology, Sydney), Brian Garner (Deakin University) and Steffen Staab (University of Karlsruhe). Eric Tsui is CSC's Chief Research Officer, Asia Pacific. He has designed and delivered the first KM course for the University of Technology, Sydney. Brian Garner is the Professor of Computing at Deakin University and is a member of the United Nations CEFACT D9/T9 Work Groups. Steffen Staab is a world-renowned researcher in the areas of ontology and organisational memory. He was also the coordinator for the AAAI Spring Symposium on "Bringing Knowledge to Business Processes" held in March, 2000.

3. Statistics and summary of papers accepted

The special issue attracted 18 submissions in total from the following countries: Australia, Canada, Germany, Hong Kong, Korea, Portugal, United Kingdom, United States and Switzerland. This response, an outstanding international effort, was most gratifying. Each paper was carefully examined by at least three reviewers. Out of the 18 submitted papers, five have been accepted as full papers together with four short papers.

Among the nine papers accepted for publication, three papers are on the use of an organisational memory to support business processes, one paper addresses an integrated framework that supports business processes, two papers address technologies for intelligent search agents, two papers describe the use of agents in the defence industry, and there is one paper on people finder KM systems. Given that up to now, publications on AI in KM are typically biased towards intelligent agents, ontologies and computer-mediated collaborations, it is especially pleasing to see the compositional balance of the papers and the strong application focus shown by all the papers in this special issue.

Abecker, Bernardi, Maus, Sintek and Wenzel have demonstrated an integrated framework that encompasses document analysis, workflow, and knowledge modelling to support knowledge-intensive business processes. In their *KnowMore* project, relevant and goal-specific information is automatically delivered to the knowledge workers. Staab and Schnurr discuss a desk support agent that predicts the critical knowledge needs in a loosely structured business process. They have illustrated a very good example of the use of an organisational memory to support business processes. Reimer, Margelisch and Staudt have, on the other hand, outlined their EULE system that is basically an OMIS that maintains and ensures that relevant business rules are applied in the various tasks carried out by office workers in an insurance company. Boury-Brisset and Tourigny outlines an organisational memory, that with the use of case-based reasoning techniques, supports the overall goal of road safety analysis.

AI and KM have a strong role to play in the defense arena too. Liebowitz, Adya, Montano, Yoon, Buchwalter, and Imhoff elaborated a Multi-Agent system for coordinating defense procurement and contracting. Lang and Burnett's paper is on a health intelligence system that uses metadata to analyse, manage and merge large sets of documents in support of Australian defence operations.

Li, Zhang and Swan's paper is on information filtering techniques to classify new documents on the WWW, based on user needs. A separately developed and simpler variant of the system has been customised to locate, match and retrieve job vacancy data from prominent Australian Job sites. Pierre, Kacan and Probst, on the other hand, addresses an intelligent search agent that, by considering individual interest profiles, integrates the needs of multiple users in conducting its search and delivers customised responses to users concurrently.

While most KM tools on the market overlook the importance of connecting people, by focusing almost entirely on searching information/documents on Intranets/WWW, Becerra-Fernandez's paper has made a distinctive contribution to the field by identifying the role of AI in several *people finder* KM systems.

This special issue concludes with an extensive bibliography on AI in KM and various KM applications. It is hoped that the bibliography will serve as a starting point for researchers and practitioners interested in furthering the role of AI in KM and KM applications in general. This is a subset of the full bibliography maintained by Dr Tsui.

4. Future intelligent systems for KM

Contemporary progress has been reported in knowledge processing, and more generally AI, in building institutional memories as the basis for business intelligence (competitive advantage) and for leveraging knowledge assets in large organisations. Functional KM roles have been identified in intelligent workflow applications, in collaborative filtering during information retrieval, in knowledge integration processes (cf. Intranets/Extranets) and in the use of intelligent agents for KD.

From an academic perspective, new paradigms are now required to meet the exacting requirements demanded by business and Government in the following areas:

- Human–computer interaction e.g. in natural language understanding (particularly in diverse cultures), real-time mining of user profiles and various personalisation strategies. Significant work is still required to integrate information from diverse sources and in the seamless presentation

of combined results (e.g. assets, people contacts, interest profiles, activities log etc.) derived from searching corporate intranets and open source material (e.g. Web sites).

- Automatic categorisation and indexing of (Web-based) documents (i.e. the so called "Semantic Web") is of immediate concern for KM and a *hot* research focus for AI. The necessary techniques that need to be developed range from knowledge structuring (Knowledge Engineering, semi-automatic acquisition of knowledge structures, ontologies in particular, intelligent information integration, emergent ontologies), to knowledge representation on the Web (i.e. formats like RDF, extensible and integrable frameworks)
- The above research will, in turn, spawn development of integrated tool environments for ontological engineering (e.g. knowledge fusion processes), for intelligent indexing mechanisms and for organisational learning.
- The link between DM/KD and KM. Although there is plenty of research on DM/KD and KM, the "link" between DM/KD and KM is very much under-explored. For instance, from the perspective of a researcher in DM/KD, the end result is, typically, the findings of (a series of) experiments. This is too often seen as the "*finishing line*" for the DM/KD researchers, as evidenced by DM/KD publications. However, in the corporate environment, such findings are then communicated to business analyst(s) and, upon further analyses, often result in the creation/alteration of business rule(s). In the entire process (i.e. from data gathering to data mining to the encoding of business rules), there are lots of intermediate decisions being taken by the DM/KD researcher(s) as well as the business analyst(s). Such decisions and the context (e.g. situational factors, assumptions, justifications etc.) in which these decisions were made are rarely recorded. The result — *organisations often cannot even reproduce the same result* even if there is no change to the data or the staffing! Current commercial AI/KM systems typically fail to support context. Different implementations of context-tracking mechanisms are needed in order to (actively) provide the right knowledge to the right person at the right time — the so-called "active corporate memory" [19]. In the longer term, intelligent and dynamic model generation systems are definitely needed to bridge the gap between expert systems, decision making and data mining tools.
- CRM processes, based on Internet/Mobile Commerce business models, are increasingly the starting point for enterprise modelling. AI researchers are thus faced with new challenges arising from the holistic approach required, rather than the current undue reliance on individual techniques and methods.

Acknowledgements

References

[1] C. O'Dell, S. Elliott, (1999 Handbook of Business Strategy), Emerging Strategies in Knowledge Management, Faulkner & Gray, New York, 1998.

[2] I. Nonaka, H. Takeuchi, The Knowledge-Creating Company, Oxford University Press, Oxford, 1995.

[3] J. Essers, J. Schreinemakers, Nonaka's Subjectivist Conception of Knowledge in Corporate Knowledge Program, Knowledge Organization 24 (1) (1997) 24–32.

[4] J.C. Spender, R.M. Grant, Knowledge and the firm-overview, Strategic Management Journal 17 (Winter) (1996) 5–9 (Special Issue SI).

[5] J.C. Spender, Making knowledge the basis of a dynamic theory of the firm, Strategic Management Journal 17 (Winter) (1996) 45–56 (Special Issue SI).

[6] M. Bonaventura, The benefits of a knowledge culture, Aslib Proceedings 49 (4) (1997) 82–89.

[7] B. Lemken, H. Kahler, M. Rittenbruch, Sustained knowledge management by organizational culture, Proceedings of the 33rd Annual Hawaii International Conference on System Sciences, 2000, p. 64.

[8] K.M. Wiig, Knowledge Management: Where did it come from and where will it go, Expert Systems with Applications 13 (1) (1997) 1–14 (September).

[9] E. Lank, Leveraging Invisible Assets: the human factor, Long Range Planning 30 (3) (1997) 406–412 (June).

[10] L. Edvinsson, Developing intellectual capital at Skandia, Long Range Planning 30 (3) (1997) 366–373 (June).

[11] K. Dovey, The learning organization and the organization of learning — Power, transformation and the search for form in learning organizations, Management Learning 28 (3) (1997) 331–349.

[12] M.R. Pitt, Strategic learning and knowledge management, in: A. Heene, R. Sanchez (Eds.), Human Relations, Human Relations, Vol. 51, No. 4, 1998, pp. 548–562 (April).

[13] R.P. Mohanty, S.G. Deshmukh, Evaluating manufacturing strategy for a learning organization: a case, International Journal of Operations and Production Management 19 (3/4) (1999) 308–327.

[14] J. Morrison, L. Olfman, Knowledge Management, organizational memory and organizational learning, Proceedings of the 33rd Annual Hawaii International Conference on System Sciences, 2000, pp. 65–66.

[15] L. Argote, Organizational Learning: Creating, Retaining, and Transferring Knowledge, Kluwer Academic, Norwell, 1999.

[16] M. Harvey, J. Palmer, C. Speier, Implementing intra-organizational learning: a phased-model approach supported by intranet technology, European Management Journal 16 (3) (1998) 341–354 (June).

[17] M. Senge, Creating learning communities, Executive Excellence 14 (3) (1997) 17–18 (March).

[18] J. Morrison, Organizational memory information systems: characteristics and development strategies, Proceedings of the 30th Hawaii International Conference on System Sciences, vol. 2, 7–10th January, 1997, pp. 300–309.

[19] G. Van Heijst, R. Van der Spek, E. Kruizinga, Corporate memories as a tool for knowledge management, Expert Systems with Applications 13 (1) (1997) 41–54.

[20] A. Rabarijaona, R. Dieng, O. Corby, Building and Searching a XML-based Corporate Memory, in: R. Dieng, guest editor, IEEE Intelligent Systems and their Applications, Special Issue on Knowledge Management and the Internet, May/June 2000.

[21] J.W. Bonney, Corporate Memory: Theory and Reality, Smart-text Solutions Inc., Canada, 1999.

[22] A. Attipoe, Knowledge structuring for corporate memory, Markup Languages: Theory and Practice Fall (1999) 27–35.

[23] J.M. Bradshaw, R. Carpenter, R. Cranfill, R. Jeffers, Roles for agent technology for knowledge management: examples from applications in aerospace and medicine, AAAI Spring Symposium on AI in KM, Technical Report SS-97-01, 1997, pp. 9–15.

[24] B.R. Gaines, Knowledge management in societies of intelligent adaptive agents, Journal of Intelligent Information Systems 9 (3) (1997) 277–298 (November–December).

[25] M. Lacher, M. Koch, An agent-based Knowledge Management framework, AAAI Workshop on Bringing Knowledge to Business Processes, 20–22 March, 2000.

[26] J. Meehan, R. Barker, L. Holloway, J. Mardell, Supporting Knowledge-based processes using flexible intelligent agents, AAAI Workshop on Bringing Knowledge to Business Processes, 20–22 March, 2000.

[27] B.G. Silverman, The role of web agents in medical knowledge management, MD Computing 15 (4) (1998) 221 (July–August).

[28] T.J.M. Bench-Capon, The role of Ontologies in the Verification and Validation of Knowledge Based Systems, Proceedings of the 9th International Workshop on Database and Expert System Applications, 26–28 August 1998, pp. 64–69.

[29] W.N. Borst, J.M. Akkermans, Engineering Ontologies, International Journal of Human-Computer Studies 46 (2/3) (1997) 365–406 (February–March).

[30] B. Chandrasekaran, J.R. Josephson, V.R. Benjamins, What are Ontologies?, and Why do we need them?, IEEE Intelligent Systems January/February (1999) 20–26.

[31] J. Domingue, Knowledge Management via Ontology Driven Document Enrichment, Workshop on Intelligent Systems in the Knowledge-Driven Economy (ISKDE), May 2000, UK.

[32] E. Motta, S. Buckingham Shum, J. Domingue, Ontology-driven document enrichment: principles, tools and applications, International Journal of Human-Computer Studies 52 (2000) 1071–1109.

[33] A. Farquhar, R. Fikes, J. Rice, The Ontolingua Server: A tool for collaborative ontology construction, International Journal of Human-Computer Studies 46 (6) (1997) 707–728 (June).

[34] T.R. Gruber, Towards principles for the design of ontologies used for knowledge sharing, International Journal of Human-Computer Studies 43 (5/6) (1995) 907–928 (November–December).

[35] H. Kim, Developing ontologies to enable knowledge management: integrating business process and data driven approaches, AAAI Workshop on Bringing Knowledge to Business Processes, 20–22 March 2000.

[36] G. Van Heijst, A.T. Schreiber, B.J. Wielinga, Using explicit ontologies in KBS development, International Journal of Human-Computer Studies 46 (2/3) (1997) 183–292 (February–March).

[37] A. Abecker, A. Bernardi, M. Sintek, Developing a knowledge management technology: an encompassing view on know more, know-net and enrich, Proceedings of the 8th IEEE International Workshops on Enabling Technologies: Infrastructure for Collaborative Enterprises, 1999, pp. 216–222.

[38] L. Levine, I. Monarch, Collaborative technology in the learning organization: integrating processes with information flow, access and interpretation, Proceedings of the 31st Hawaii International Conference on System Sciences, vol. 1, 1998, pp. 444–459.

[39] B. Ramesh, A. Tiwana, Supporting collaborative process knowledge management in new product development teams, Decision Support Systems 27 (November) (1999) 213–235.

[40] M. Schrage, in: R.L. Rudy (Ed.), Collaborative Tools: A First Look, in Knowledge Management Tools, Butterworth-Heinemann, Boston, 1997.

[41] D. Cecez-Kecmanovic, C. Webb, in: A.K. Aggarwal (Ed.), A critical inquiry into Web-mediated collaborative learning, in Web-based learning: Opportunities and Challenges, IDEA Group Publishing, PA, 2000, pp. 307–326.

E. Tsui[a,*]
B.J. Garner[b]
S. Staab[c]
*[a]Computer Sciences Corporation
and University of Technology,
Sydney, Australia
E-mail address:* eric_tsui@csc.co.nz
*[b]School of Computing and Mathematics,
Deakin University,
Geelong, Victoria, 3217,
Australia
[c]Institute AIFB,
Karlsruhe University,
D-76128 Karlsruhe,
Germany*

* Corresponding author.